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COMPARISON OF THE EFFECTIVENESS OF FOUR DIFFERENT TYPES OF NEED--ETC(U)
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COMPARISON OF THE EFFECTIVENESS OF FOUR DIFFERENT TYPES OF NEEDLES IN IRRIGATING ENDODONTICALLY TREATED TEETH

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ABSTRACT

A gel containing radioactive ^{125}I-albumin was used to determine the effectiveness of four different types of irrigating needles in the removal of contamination in vitro from the root canals of forty endodontically treated single-rooted human teeth. All of the needles tested were equally effective in removal of the radioactive tracer from the root canals. Regardless of needle design, more tracer remained in the apical four and eight millimeter segments after irrigation than was present prior to irrigation.

INTRODUCTION

One of the prerequisites for successful endodontic therapy is the removal of pulp tissue and dentin debris in the root canal space. Much emphasis has been placed on the need for irrigation of the root canal because of the bactericidal and cleansing benefits of the irrigating agents.[1-4] The controversy as to which irrigating solution is more efficacious is yet unresolved.[5-8]

It is generally accepted that the occlusal portion of the root canal space can be adequately cleansed with an irrigant using a standard method of irrigation. It is the apical third which appears to present a problem. Senia, Marshall, and Rosen[9] investigated the cleansing effect of sodium hypochlorite and normal saline on the apical one third using a standard irrigating method. They found that sodium hypochlorite was no better than normal saline solution in irrigating this segment. Salzgeber and Brilliant[10] investigated the penetration of irrigants using a radiopaque solution. They found that irrigants penetrated adequately to the apical third of the canal space, but this did not necessarily insure adequate cleansing of the area. Svec and Harrison,[6] unlike Senia _et al._[9], found that a combination of sodium hypochlorite and hydrogen peroxide produced a significantly cleaner canal in the apical third than saline used alone. This difference may have been due to the use of mesial canals of mandibular molars by Senia _et al._[9] while Svec and Harrison[6] used single rooted anterior teeth. The larger canal spaces of the single rooted teeth should have allowed

for deeper penetration of the irrigation needles. Baker, Eleazer, Auerbach, and Seltzer[5] concluded that the type of irrigating solution was less important than the quantity of irrigant in cleansing the root canal space. Saline was recommended for irrigation because it is the most biologically acceptable irrigating solution. McComb and Smith[8] and Martin[11] concluded that standard irrigants such as sodium hypochlorite, saline or a combination of hydrogen peroxide and sodium hypochlorite were unable to completely remove superficial debris and the "smeared layer"[8] from the dentin.

As indicated by the Senia _et al._[9] and Svec and Harrison[6] studies, a possible handicap in thoroughly cleansing the apical third is the inability of the standard irrigating needle to flush this area of the canal.

In the standard method described in textbooks,[12,13] a blunted 23-gauge needle is inserted into the root canal orifice, approximately halfway to the apex or until the needle fits freely without binding. The irrigant is then introduced into the canal space and is supposed to carry the debris occlusally. The loosely fitted needle used with minimal irrigating pressure should preclude forcing the solution through the apical foramen. The detrimental effects of forcing sodium hypochlorite into the periapical region has been reported by Becker _et al._[14]

In order to achieve better cleansing of the apical third of the root canal space and to avoid forcing irrigants through the apex, Goldman, Kronman, Goldman, Clausen, and Grady[15] introduced a new type

of irrigating needle.* The needle is 31 mm long, closed at the end, and has ten perforations along its shaft from 2 - 15 mm from the tip. The needle is available in several different gauges so that it can be inserted to within 1 mm of the apex. Recently Goldman et al.[16] have claimed more efficiency with this needle. Unfortunately, the claim appears to be founded on subjective analysis based on the observers' impression of scanning electron microscope data.

The purpose of this in vitro study was to evaluate four different types of needles for their effectiveness in removing ^{125}I-albumin from endodontically treated root canals.

METHODS AND MATERIALS

The four types of irrigating needles utilized in the study were:

1. 23-gauge open ended endodontic needles.#

2. 26-gauge closed end needles - with ten perforations along the shaft as suggested by Goldman et al.[15,16]

3. A prototype endodontic needle made by cutting off the pointed tip of a standard 26-gauge hypodermic needle,# sealing the end with solder and placing two perforations on the shaft. One perforation was placed 1 mm from the sealed end while the other was placed 3 mm from the end, opposite from the first.

4. 26-gauge standard hypodermic needle# (1-5/8" long) open at the end with a tapered point.

Collection and Preparation of Teeth

Fifty extracted, single-rooted, human permanent teeth were

*National Patent Development Corp., New York, N.Y.
#Becton-Dickinson, Rutherford, N.J. 07070

collected, stored in glutaraldehyde and later randomly distributed into five groups of ten each (Groups 1-5). A basic method of endodontic preparation as presented by Svec and Harrison[6] was utilized to instrument the root canals. Occlusal or lingual access openings were made using high speed round burs and slow speed long shank round burs. In order to determine the working lengths, a #10 file was passed through the canal space until it was visualized at the apical opening. The working length was determined to be 1 mm short of the apical opening and recorded for each tooth. At this time shallow grooves were placed through the cementum into the dentin 4 mm and 8 mm from the apex to guide future separation. Wax was placed around the apex of the teeth in order to prevent the extrusion of irrigating solution and dentinal debris during instrumentation. For purposes of standardizing instrumentation, all canals were instrumented to the working length using only type B[+] files. Each successive instrument size was manipulated for 30 seconds followed by irrigation with 2 ml of normal saline, using a standard 23-gauge needle and plastic syringe. The final instrument used was a #55 file at the working length of each tooth. At the conclusion of instrumentation, the canals were irrigated with 5 ml of normal saline and dried with paper points. Each tooth was painted with two coats of clear enamel to decrease surface permeability. Leaving only the occlusal access openings exposed, a layer of pink baseplate was applied to each tooth as a precaution against radioactive contamination of the exterior surfaces.

+Kerr Manufacturing, Sybron Corp., Romulus, Mich.

Experimental Treatment of Teeth

Radioactive albumin solution was prepared by adding 1 ml of ^{125}I-albumin% containing 0.821 microcuries of radioactivity to 1.5 ml of a heated 3.5% gelatin" solution. This yielded a gelatin solution containing 0.328 microcuries of ^{125}I-albumin/ml. This solution was warmed during the experiment to maintain liquidity.

The canals of the teeth were injected with the radioactive solution through the occlusal access from the apex to the floor of the pulp chamber using a 26-gauge needle attached to a 1 cc tuberculin syringeø (approximately 20 microliters per tooth). When cooled, the solution formed a water soluble radioactive gel. The initial level of radioactivity, which was used as the base line for establishing the contamination of each tooth, was determined by placing each tooth into a clear plastic gamma counting tube and counting in a gamma scintillation radiation counter.@

The teeth in the experimental groups were all irrigated with 5 ml of normal saline. Those from Group I were treated by placing a 23-gauge irrigating needle into each canal until the needle bound. It was then withdrawn approximately 3 mm and the canal irrigated. Teeth from Group II were irrigated with the needles advocated by Goldman et al.[15,16] placed to the working length then withdrawn 1 mm. Teeth from Group III were irrigated with the modified needles placed to the working length and withdrawn 1 mm. Teeth from Group IV were irrigated with 26-gauge open-ended needles placed to the working length and withdrawn 1 mm. Excess solution was aspirated from each

%NEX-076, New England Nuclear, Boston, MA
"Knox Gelatine, Inc., Englewood Cliffs, NJ
øBecton-Dickinson, Rutherford, NJ
@Tracor Analytic, Model 1185 Automatic Gamma System, Elk Grove Village, ILL

canal after irrigation with the empty 5 cc syringe and irrigating needle. Excess irrigant at the occlusal opening was wiped quickly away with laboratory suction. The baseplate wax covering each tooth was removed and the amount of remaining radioactivity was determined.

Each tooth was then divided into an apical 4 mm, a middle 4 mm, and coronal section by cutting through the previously placed grooves with a separating disc in a closed hood. Each tooth section was then placed into a separate tube and the radioactivity was determined.

As a control, ten teeth (Group V) were prepared in the same manner, filled with radioactive gel and base line radioactivity determined. They were then sectioned without irrigation and recounted. This allowed an estimation of percentage of radioactivity in each section prior to irrigation.

RESULTS

Table 1 shows the mean initial radioactivity in the root canals of each of the four experimental groups as well as the total radioactivity remaining in the sectioned teeth after irrigation with 5 ml of saline. It shows that irrigation by itself was effective in in removing only 32 - 46% of the total contamination from the canals. Analysis of the reduction in radioactivity, using the Student's paired "t" test,[17] showed that this reduction was statistically significant for Groups I through III at $p<0.01$. As expected there was no significant difference between the initial radioactivity and

the radioactivity after sectioning of Group V.

An analysis of variance[18] was done on the radioactivity remaining in the complete root canal of each of the four groups studied. This analysis shows that no statistical difference could be shown in the ability to remove radioactivity of any of the types of needles tested. ($F = 1.67$ ns)

While there did not appear to be any difference in the total amount of radioactivity removed, there was the possibility that one of the needles could have cleaned one section of the root canal better than another needle. In order to test for this possibility, the teeth were divided into sections and each segment was counted. Analyses of variances were calculated on the radioactivity levels in the apical, middle and coronal sections of all of the four groups. Of the four irrigated groups studied, no significant difference was noted in the distribution of radioactivity in the apical, middle or coronal sections of the root canals. (Apical segment $F = 0.176$, ns; middle segment $F = 2.649$, ns; coronal segment $F = 1.582$, ns)

Figure 1 shows the mean radioactivity remaining in the apical, middle and coronal sections of the root canals after irrigation with the four experimental needles as compared with the pre-rinse radioactivity in the whole canal. In the experimental groups, the apical sections contained 6.3 - 8.4% of radioactivity after irrigation whereas the control (Group V) contained only 4.6% without irrigation. The middle experimental group sections contained 16.8 - 25.3% after irrigation whereas the control showed 14.3% without irrigation. The

coronal experimental group sections contained 28.1 - 34.4% after irrigation whereas the control showed 67.3% without irrigation.

Table 2 reflects the results of analysis of variance done on the distribution of radioactivity within the canals of each of the groups tested. It shows that there was a significant difference in the distribution of radioactivity in each of the groups tested. Post hoc comparisons of the values shown in Figure 1 were done using Tukey's HSD (Honestly Significant Difference Test).[17] This test showed that the differences in distribution within the root canals were significant at $p<0.01$ for all of the groups; that is, amount of radioactivity in apical, middle and coronal portions of the teeth were significantly different from each other in each group. This distribution of the radioactivity is probably more a function of the variable total tooth volumes rather than any irrigating property of the tested needles.

DISCUSSION

In a recent study by Weller, Brady, and Bernier,[19] ^{125}I-albumin was used in an evaluation of hand instrumentation and ultrasonic cleansing of the root canal system. In this study, ^{125}I-albumin was also used in hopes of more closely simulating the clinical conditions within the root canal system; that is, irrigation in the presence of protein and/or their breakdown products.

Goldman et al.[15,16] postulated that irrigation of canals during endodontic therapy could be more readily accomplished by modifying the type of needle as well as its method of use. In this study, four

different needles were compared to determine if the design, in fact, enhanced the removal of radioactive material during irrigation under simulated clinical conditions. No statistical difference could be shown among the needles tested (Table 1). Approximately 32 - 46% of the totally injected radioactivity was removed by irrigation and sectioning regardless of the needle design. This left 54 - 68% in the canals or forced into dentinal tubules and accessory canals. Another factor for the low removal of radioactivity from the canals may be related to the use of only 5 cc of irrigant.

Since debridement of the apical portion of the root canal is important in endodontic therapy, attention was given to the individual sections in Figure 1. It is interesting to note the relative increase in percentage of radioactivity in both the apical and middle sections of the experimental teeth over that of the control. It is suggested, therefore, that the lateral pressure imparted by the dynamics of irrigation forces ^{125}I-albumin into the dentinal tubules and accessory canals at a greater magnitude than that by which it is removed from the main root canal space. It can only be stated that within the limits of this experiment, no needle type was more efficacious than any other in removing the radioactive material from that measured section of the root canal.

In clinical practice, irrigation would be followed by drying of the canals with a paper point. This process might remove more of the contaminants left in the canal space itself and perhaps some from

the dentinal tubules. Some of the remaining radioactivity may be contained in the "smeared layer" referred to by McComb and Smith.[8] It is also possible that the "smeared layer" is an artifact created by irrigation. It is postulated that as the irrigating solution flows apically into the canal, swirls around and exits through the occlusal access, some of the debris from instrumentation is deposited along the canal walls and into the open dentinal tubules forming the "smeared layer." Whether the "smeared layer" would be partially removed by paper points or reinstrumentation needs further study.

SUMMARY AND CONCLUSIONS

Fifty single-rooted human teeth were instrumented to a size #55 file. The teeth were divided into four experimental groups of ten for testing the effectiveness of four different types of irrigating needles. One additional group of ten teeth was used as controls without being irrigated. A radioactive ^{125}I-albumin gel was placed into the prepared canals of the teeth, allowed to cool and the initial radioactive level in each tooth determined. The canals of Groups I through IV were then irrigated with 5 ml of normal saline through one of the corresponding test needles. The teeth in Group I were irrigated with 23-gauge needles placed into the canals up to 8 mm from the working length without binding. Teeth in Group II were irrigated with 26-gauge needles, as advocated by Goldman _et al._[15,16], placed about 1 mm from the working length. Teeth in Groups III and IV were irrigated with

modified closed-end and open-ended 26-gauge needles respectively, also placed within 1 mm of the working length. The teeth in Group V were not irrigated. Each tooth was then sectioned into apical, middle and coronal segments and the radioactivity was determined.

In summary, it can be stated that:

1. No needle appeared to remove the radioactive material from the canals better than any other needle.
2. Of the initial radioactivity placed, approximately 54 - 68% remained in the teeth after irrigation and sectioning.
3. Irrigation alone was not effective in removing the radioactive contamination from the apical 4 mm of the root canal.

Further studies are being conducted to determine the effects of larger quantities of irrigating solutions as well as the influence of post-irrigation instrumentation and paper point drying.

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TABLE 1

Effects of irrigation on removal of radioactive ^{125}I-albumin from the root canals of endodontically prepared teeth

Group	^{125}I CPM Whole Tooth Initial (a)	^{125}I CPM Post Irrigation Total of Sections	% Radioactivity Remaining in Canal Sections
I 23-gauge Blunted Needle	7481 ± 2209	4302 ± 1319 $p<0.001$ (b)	57.5 ± 17.5 (c)
II 26-gauge Goldman Needle	10537 ± 2332	5732 ± 1248 $p<0.001$	54.4 ± 11.8
III 26-gauge Modified Needle	8139 ± 1813	4859 ± 987 $p<0.001$	59.7 ± 9.5
IV 26-gauge Unmodified Needle	8792 ± 1957	5961 ± 1346 $p<0.01$	67.8 ± 16.4
V Not Irrigated	13619 ± 2739	11740 ± 4152 (d) NS	86.2 ± 30

a. Mean ± Standard Deviation of 10 teeth. ^{125}I radioactivity was counted in a Tracor Analytical Model 1185 Automatic Gamma Scintillation Counter using a 3" Na Iodide crystal which counted ^{125}I at 76% efficiency.

b. Statistical Significance - utilizing the 2 tailed Student's "t" test for paired samples.[17,18]

c. Mean ± Standard Deviation of 10 teeth. Calculated from comparison of the pre-rinse whole tooth to the post-rinse ^{125}I radioactivity of each tooth after sectioning.

d. Mean ± Standard Deviation of 10 teeth. Calculated from comparison of ^{125}I radioactivity of the whole tooth to the sum of the individual sections not irrigated.

TABLE 2

Summary of analysis of variance comparing the distribution of radioactivity remaining in the apical, middle and coronal sections of each tooth in each experimental group after irrigation

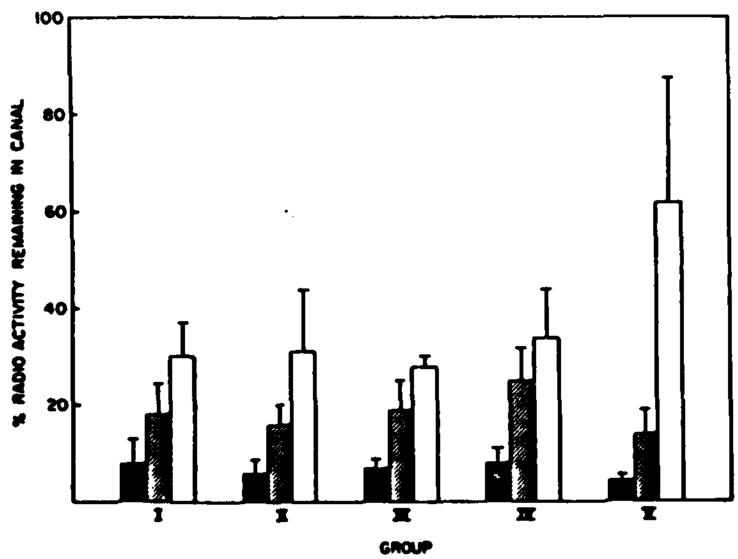
Source	df	SS	MS	F	P
Group I (23-gauge needle)					
Between	2	0.909	0.454	55.00	0.01
Within	27	0.223	0.008		
Total	29	1.132			
Group II (Goldman's 26-gauge needle)					
Between	2	0.980	0.490	37.21	0.01
Within	27	0.356	0.013		
Total	29	1.336			
Group III (Modified 26-gauge needle)					
Between	2	0.684	0.342	185.54	0.01
Within	27	0.049	0.002		
Total	29	0.734			
Group IV (Unmodified 26-gauge needle)					
Between	2	0.770	0.385	98.59	0.01
Within	27	0.105	0.004		
Total	29	0.876			

LEGEND

Figure 1

Percent Distribution of Radioactivity Remaining in Post Irrigated Root Canal Sections.

Each observation is the mean ± standard deviation of 10 samples. The percent distribution was calculated by dividing the radioactivity determined in each segment by the initial radioactivity present in the whole tooth. The solid bars show the residual radioactivity in the apical 4 mm, the bars filled with diagonal lines shows the residual radioactivity in the middle 4 mm of the tooth, and the open bars show the residual radioactivity in the remaining coronal section of the tooth. The standard deviation for each group is indicated by the capped line over each bar.



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